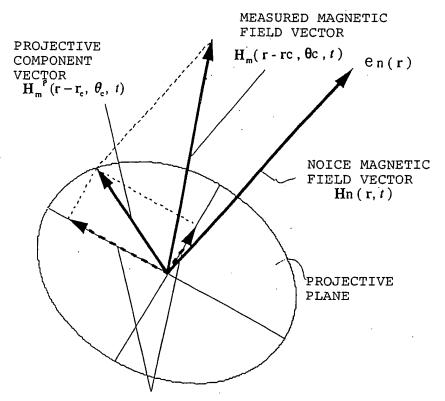
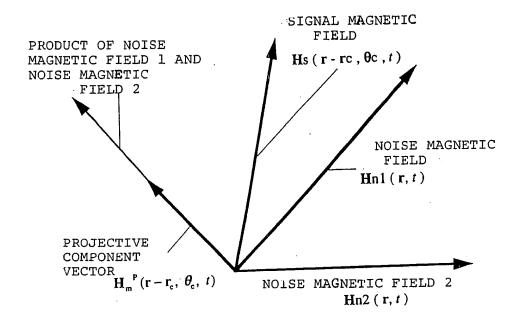


PLANE PERPENDICULAR TO VERTICAL DIRECTION

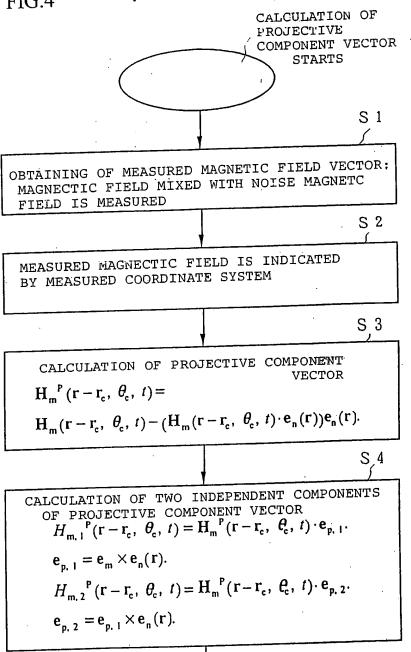




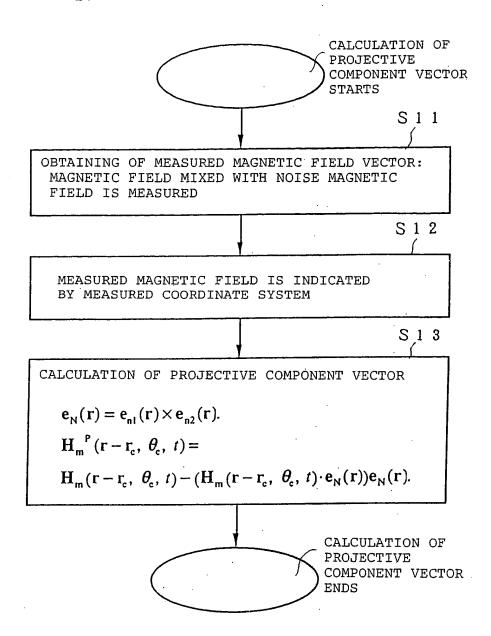
PROJECTIVE COMPONENT VECTOR
DECOMPOSED TO TWO ORTHOGONAL
VECTORS



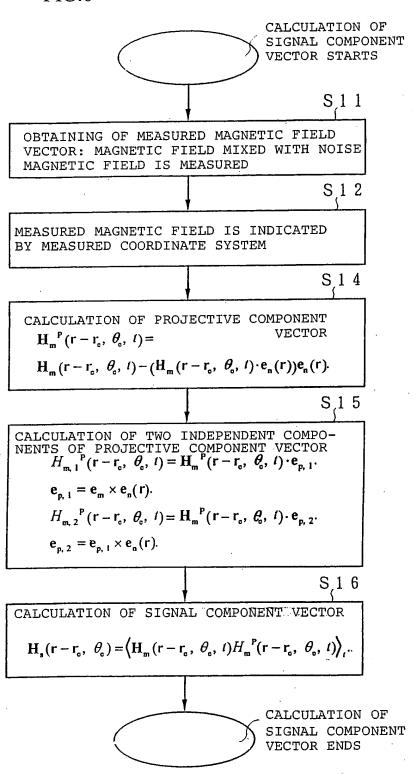




CALCULATION OF PROJECTIVE COMPONENT VECTOR ENDS









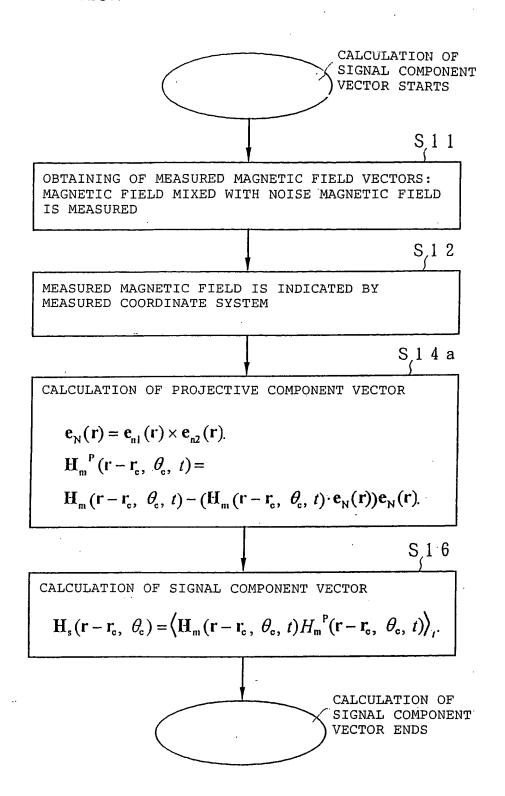
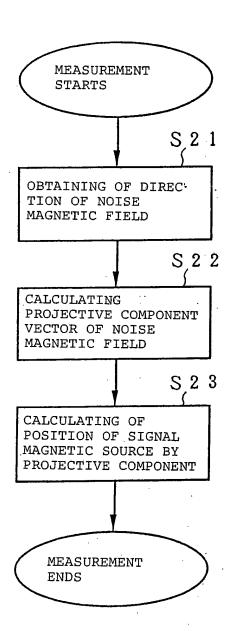
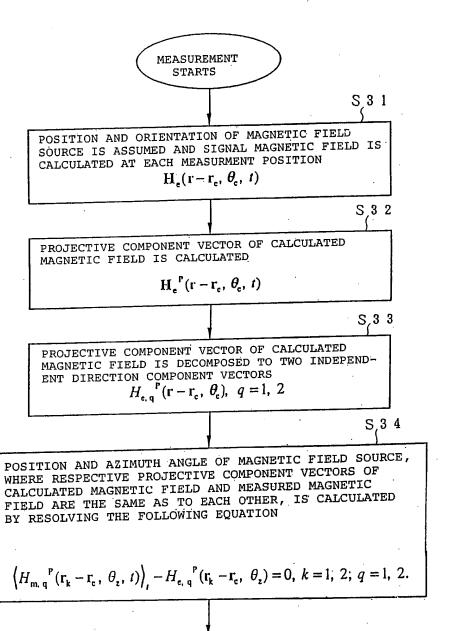




FIG.8





MEASUREMENT



MEASUREMENT STARTS

S,4 1

POSITION AND ORIENTATION OF MAGNETIC FIELD SOURCE IS ASSUMED AND SIGNAL MAGNETIC FIELD IS CALCULATED AT EACH MEASURMENT POSITION  $H_e(r-r_e, \theta_e, t)$ 

S, 4 2

PROJECTIVE COMPONENT VECTOR OF CALCULATED MAGNETIC FIELD IS CALCULATED

 $H_e^P(r-r_e, \theta_e, t)$ 

PROJECTIVE COMPONENT VECTOR OF CALCULATED MAGNETIC FIELD IS DECOMPOSED TO TWO INDEPENDENT DIRECTION COMPONENT VECTORS  $H_{e,q}$  (r-r<sub>e</sub>,  $\theta_e$ ), q=1,2

S, 4 4

POSITION AND AZIMUTH ANGLE OF MAGNETIC FIELD SOURCE. WHERE RESPECTIVE PROJECTIE COMPONENT VECTORS OF CALCULATED MAGNETIC FIELD AND MEASURED MAGNETIC FIELD ARE THE SAME AS TO EACH OTHER, IS CALCULATED BY RESILVING THE FOLLOWING EQUATION

$$\min_{\mathbf{r}_{c}, a} \left\{ \sum_{k=1}^{N_{m_{c}}} \sum_{q=1}^{2} w_{k, q} \middle| \left\langle H_{m_{c} q}^{P} (\mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}, t) \right\rangle_{t} - H_{c, q}^{P} (\mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}) \right\}.$$

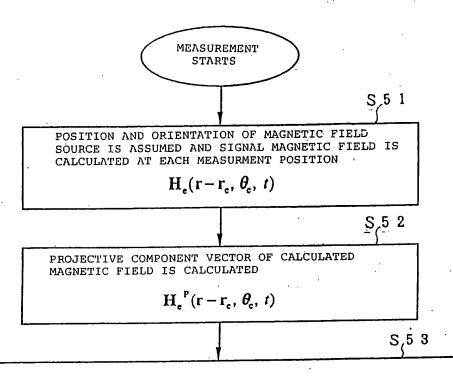
$$\min_{\substack{\mathbf{r}_{c}, \ \mathbf{q} \ \text{or}}} \left\{ \sum_{k=1}^{N_{m}} \sum_{q=1}^{2} w_{k, q} \middle| \sqrt{\middle| H_{m, q}|^{p} (\mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}, t)^{2} \middle|_{t}} - H_{c, q}|^{p} (\mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}) \middle|_{t} \right\}.$$

$$\min_{\mathbf{r}_{c}, \theta_{t}} \left\{ \sum_{k=1}^{N_{m}} \sum_{q=1}^{2} W_{k, q} \middle| \left\langle H_{m, q}^{P} (\mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}, t) \right\rangle_{t} - H_{c, q}^{P} (\mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{z})^{2} \right\}.$$

$$\min_{\mathbf{r}_{c}, \theta_{z}} \left\{ \sum_{k=1}^{N_{m}} \sum_{q=1}^{2} w_{k, q} \left| \sqrt{\left| H_{m, q}^{P} \left( \mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}, t \right)^{2} \right\rangle_{t}} - H_{c, q}^{P} \left( \mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{z} \right)^{2} \right\}$$

MEASUREMENT ENDS



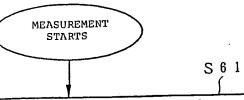


POSITION AND AZIMUTH ANGLE OF MAGNETIC FIELD SOURCE, WHERE RESPECTIVE PROJECTIVE COMPONENT VECTORS OF CALCULATED MAGNETIC FIELD AND MEASURED MAGNETIC FIELD ARE THE SAME AS TO EACH OTHER, IS CALCULATED BY RESOLVING THE FOLLOWING EQUATIONS

$$\langle H_{\rm m}^{P}(\mathbf{r}_{\rm k} - \mathbf{r}_{\rm c}, \theta_{\rm c}, t) \rangle_{t} - H_{\rm c}^{P}(\mathbf{r}_{\rm k} - \mathbf{r}_{\rm c}, \theta_{\rm c}) = C, k = 1, \dots, N_{U}.$$

MEASUREMENT ENDS





POSITION AND ORIENTATION OF MAGNETIC FIELD SOURCE IS ASSUMED AND SIGNAL MAGNETIC FIELD IS CALCULATED AT EACH MEASURMENT POSITION

$$H_e(r-r_e, \theta_e, t)$$

S 6 2

PROJECTIVE COMPONENT VECTOR OF CALCULATED MAGNETIC FIELD IS CALCULATED

$$H_e^P(r-r_e, \theta_e, t)$$

S<sub>6</sub> 3

POSITION AND AZIMUTH ANGLE OF MAGNETIC FIELD SOURCE, WHERE CALCULATED MAGNETIC FIRLD AND MEASURED MAGNETIC FIELD ARE THE SAME IN MAGNITUDE AS TO EACH OTHER, IS CALCULATED BY RESOLVING THE FOLLOWING EQUATIONS

$$\min_{\mathbf{r}_{c},\ \boldsymbol{\theta}} \left\{ \sum_{k=1}^{N_{m}} W_{k} \middle| \left\langle \middle| H_{m}^{P} (\mathbf{r}_{k} - \mathbf{r}_{c}, \ \boldsymbol{\theta}_{c}, \ \boldsymbol{I}) \middle| \right\rangle_{I} - H_{e}^{P} (\mathbf{r}_{k} - \mathbf{r}_{c}, \ \boldsymbol{\theta}_{c}) \middle| \right\}.$$

Οľ

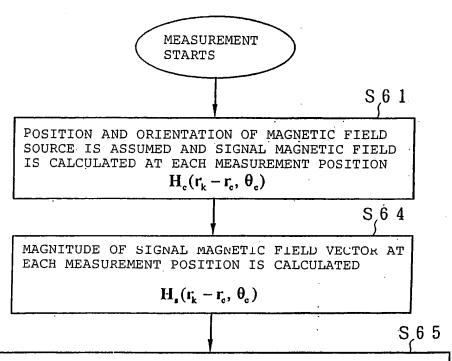
$$\min_{\mathbf{r}_{c}, \ \mathbf{d}} \left\{ \sum_{k=1}^{N_{m}} w_{k} \middle| \sqrt{\left(H_{m}^{P} \left(\mathbf{r}_{k} - \mathbf{r}_{c}, \ \boldsymbol{\theta}_{c}, \ \boldsymbol{I}\right)^{2}\right)_{l}} - H_{c}^{P} \left(\mathbf{r}_{k} - \mathbf{r}_{c}, \ \boldsymbol{\theta}_{c}\right) \right| \right\}.$$

or

$$\min_{\mathbf{r}_{i}, \theta_{i}} \left\{ \sum_{k=1}^{N_{m}} w_{k} \middle| \left\langle \middle| H_{m}^{P} \left( \mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}, t \right) \middle| \right\rangle_{i} - H_{c}^{P} \left( \mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c} \right)^{2} \right\}.$$

or

$$\min_{t_{i},\theta_{i}} \left\{ \sum_{k=1}^{N_{m}} w_{k} \middle| \sqrt{\left\langle H_{m}^{P} \left( \mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c}, t \right)^{2} \right\rangle_{i}} - H_{o}^{P} \left( \mathbf{r}_{k} - \mathbf{r}_{c}, \theta_{c} \right)^{2} \right\}.$$



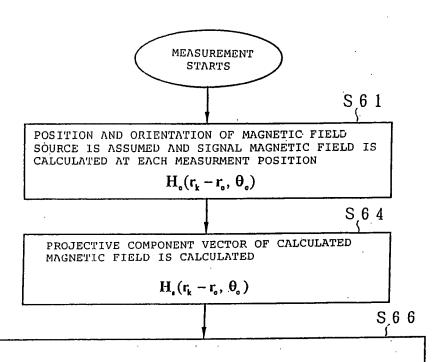
POSITION AND AZIMUTH ANGLE OF MAGNETIC FIELD SOURCE, WHERE CALCULATED MAGNETIC FIRLD AND MEASURED MAGNETIC FIELD ARE THE SAME IN MAGNITUDE AS TO EACH OTHER, IS CALCULATED BY RESOLVING THE FOLLOWING EQUATION

$$H_{s}(r_{k} - r_{c}, \theta_{c}) - H_{c}(r_{k} - r_{c}, \theta_{c}) = 0, k = 1, ..., N_{m}$$





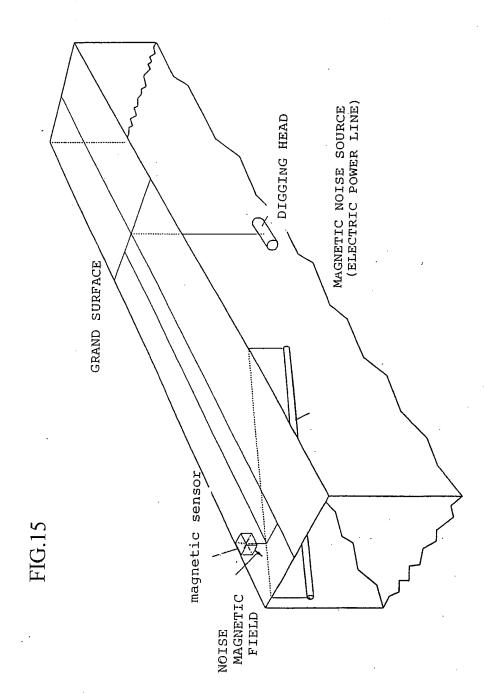
FIG.14



POSITION AND AZIMUTH ANGLE OF MAGNETIC FIELD SOURCE, WHERE CALCULATED MAGNETIC FIRLD AND MEASURED MAGNETIC FIELD ARE THE SAME IN MAGNITUDE AS TO EACH OTHER, IS CALCULATED BY RESOLVING THE FOLLOWING EQUATIONS

$$\begin{aligned} & \underset{r_{e}, \theta_{e}}{\min} \left\{ \sum_{k=1}^{N_{m}} w_{k} \middle| H_{s}(r_{k} - r_{o}, \theta_{o}) - H_{o}(r_{k} - r_{o}, \theta_{o}) \middle| \right\}. \\ & \underset{r_{e}, \theta_{e}}{\min} \left\{ \sum_{k=1}^{N_{m}} w_{k, (} \middle\| H_{s}(r_{k} - r_{o}, \theta_{o}) \middle\| - \middle\| H_{o}(r_{k} - r_{o}, \theta_{o}) \middle\| \right)^{2} \right\}. \\ & \underset{r_{e}, \theta_{s}}{\min} \left\{ \sum_{k=1}^{N_{m}} w_{k} \middle| H_{s}(r_{k} - r_{o}, \theta_{o}) - H_{o}(r_{k} - r_{o}, \theta_{o}) \middle|^{2} \right\}. \end{aligned}$$

MEASUREMENT ENDS





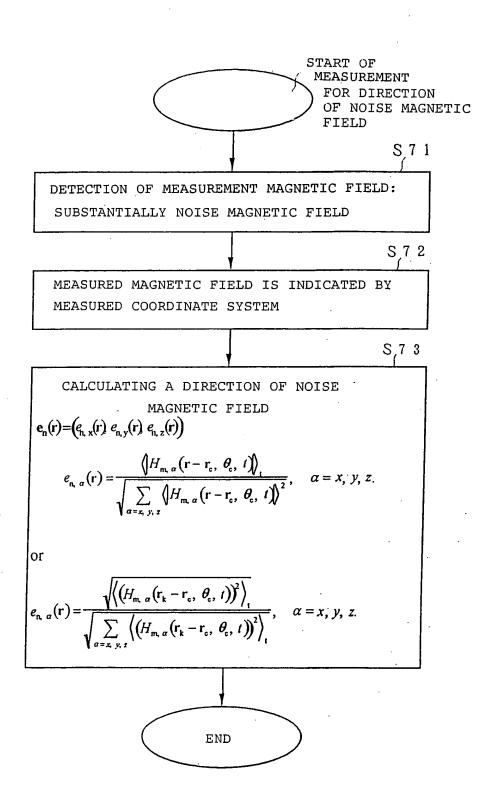
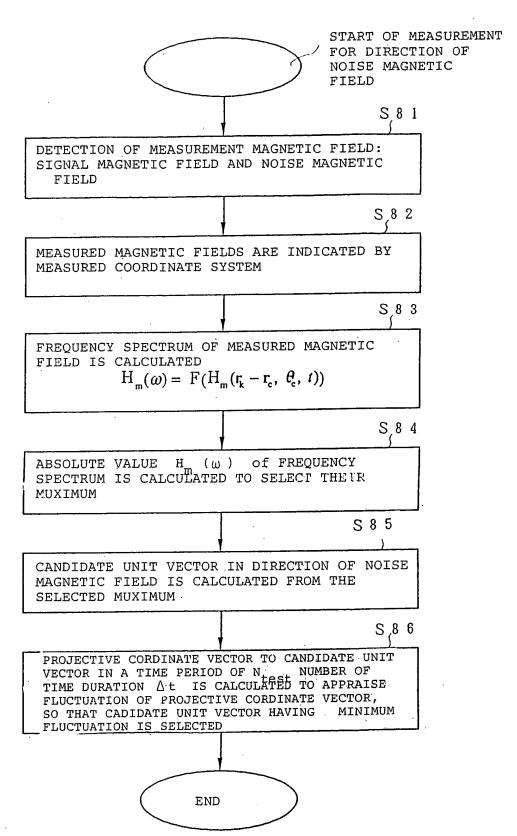
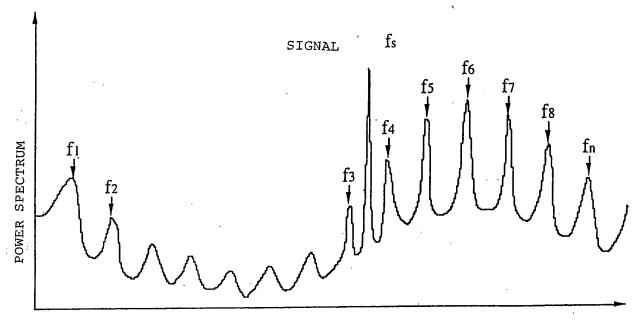




FIG.17

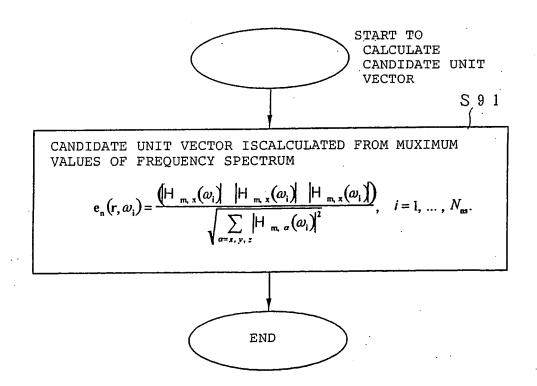


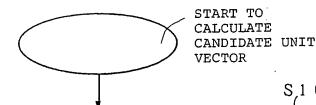




FREQUENCY

FIG.19





S<sub>.</sub>1 0 1

FROM MUXIMUM VALUES OF FREQUENCY SPECTRUM DERIVED BY FILTERING AT CORRESPONDING CENTER FREQUENCY, CORRESPONDING FREQUENCY COMPONENTS IN THE MEASURED MAGNETIC FIELD

FROM FREQUENCY COMPONENTS DERIVED BY FILTERING, CANDIDATE UNIT VECTOR

$$e_n(r) = (e_{n,x}(r), e_{n,y}(r), e_{n,z}(r))$$

ARE CALCULATED BY ANY OF FOLLOWING PROCEDURES

$$e_{n, \alpha}(\mathbf{r}, \omega_i) = \frac{\left\langle \left| H_{m, \alpha}(\mathbf{r} - \mathbf{r}_c, \theta_c, \omega_i, t) \right\rangle \right\rangle_1}{\sqrt{\sum_{\alpha = x_i, y_i, z}} \left\langle \left| H_{m, \alpha}(\mathbf{r} - \mathbf{r}_c, \theta_c, \omega_i, t) \right\rangle \right\rangle^2},$$

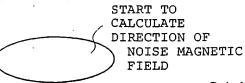
$$\alpha = x, y, z; i = 1, ..., N_{res}$$

OR

$$e_{n, \alpha}(\mathbf{r}, \omega_{i}) = \frac{\sqrt{\langle (H_{m, z}(\mathbf{r}_{k} - \mathbf{r}_{e}, \theta_{e}, \omega_{i}, t))^{2} \rangle_{t}}}{\sqrt{\sum_{\alpha = x, y, z} \langle (H_{m, \alpha}(\mathbf{r}_{k} - \mathbf{r}_{e}, \theta_{e}, \omega_{i}, t))^{2} \rangle_{t}}},$$

$$\alpha = x, y, z; i = 1, ..., N_{ns}$$

END



S<sub>1</sub>111

PROJECTIVE CORDINATE VECTOR TO CANDIDATE UNIT VECTOR IN A TIME PERIOD OF N. NUMBER OF TIME DURATION  $\Delta\,t\,$  is calculated

$$\mathbf{H}_{m}^{P}(\mathbf{r} - \mathbf{r}_{c}, \; \theta_{c}, \; \omega_{i}, \; t) = \mathbf{H}_{m}(\mathbf{r} - \mathbf{r}_{c}, \; \theta_{c}, \; t)$$

$$- (\mathbf{H}_{m}(\mathbf{r} - \mathbf{r}_{c}, \; \theta_{c}, \; t) \cdot \mathbf{e}_{n}(\mathbf{r}, \; \omega_{i})) \mathbf{e}_{n}(\mathbf{r}, \; \omega_{i}), \; i = 1, \; \dots, \; N_{m}.$$

S, 1 1 2

VARIATION OF PROJECTIVE COMPONENT  $\nu_{\text{eval}, k}$  (  $\omega_{\text{i}}$ ),  $k = 1, ..., N_{\text{test}}$ 

$$v_{\text{eval, k}}(\omega_{i}) = \left\langle H_{\text{m, q}}^{\text{p}}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, \omega_{i}, t) \right\rangle_{\mathbf{T}_{c,k}}, q = 1, 2; k = 1, ..., N_{\text{test}}; i = 1, ..., N_{\text{ns}}.$$
OR

$$\nu_{\mathrm{eval, k}}(\omega_{i}) = \left\langle \left\langle \mathbf{H}_{\mathrm{m}}^{\mathrm{P}}(\mathbf{r} - \mathbf{r}_{\mathrm{c}}, \ \boldsymbol{\ell}_{\mathrm{c}}, \ \omega_{i}, \ t \right\rangle \right\rangle_{\mathsf{T_{ck}}}, \ k = 1, \ldots, N_{\mathrm{test}}; \ i = 1, \ldots, N_{\mathrm{ns}}.$$

OR

$$v_{\text{eval, k}}(\omega_{l}) = \left\langle \left(H_{m, q}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, \omega_{l}, t)\right)^{2}\right\rangle_{T_{c, l}},$$

 $q = 1, 2; k = 1, ..., N_{test}; i = 1, ..., N_{ns}.$ 

OR

$$v_{\text{eval, }k}(\omega_{i}) = \sqrt{\left(H_{\text{m, q}}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, \omega_{i}, t)\right)^{2} \right)_{T_{c,t}}},$$

$$q = 1, 2; k = 1, ..., N_{\text{test}}; i = 1, ..., N_{\text{ns}}.$$

S,113

CANDIDATE UNIT VECTOR HAVING MINIMUM ONE OF FOLLOWING VARIANCE IS SELECTED AS DIRECTION OF NOUSE MAGNETIC FIELD

$$var(\omega_i) = \frac{\sqrt{\operatorname{mean}_{k((v_{eval, k}(\omega_i) - \operatorname{mean}_{k}(v_{eval, k}(\omega_i)))^2)}}}{\operatorname{mean}_{k(v_{eval, k}(\omega_i))}, i = 1, \dots, N_{ns}$$

END



FIG.22

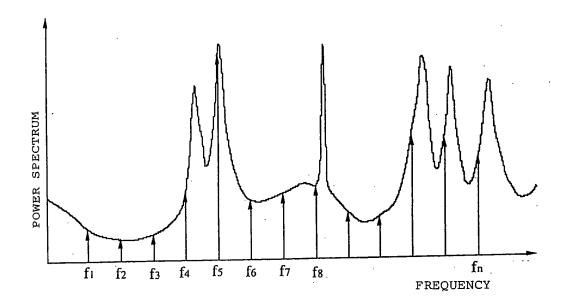




FIG.23

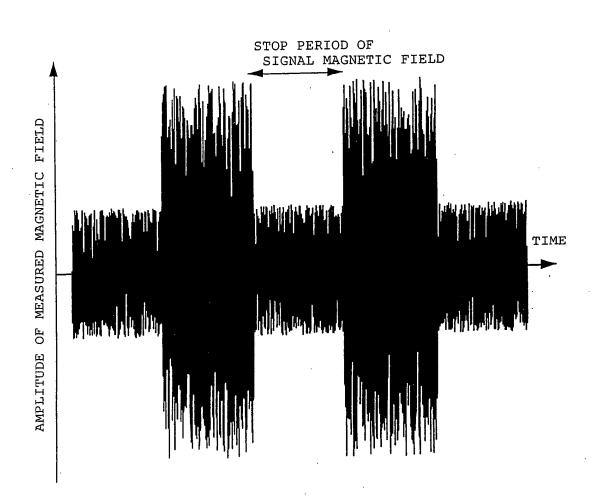




FIG.24

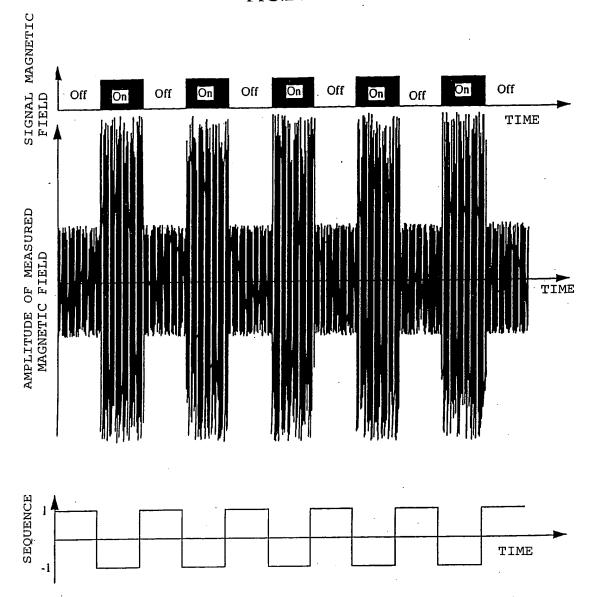
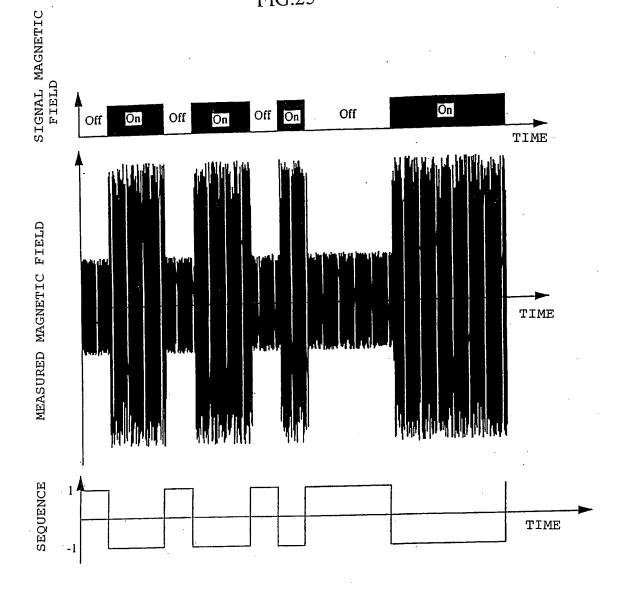
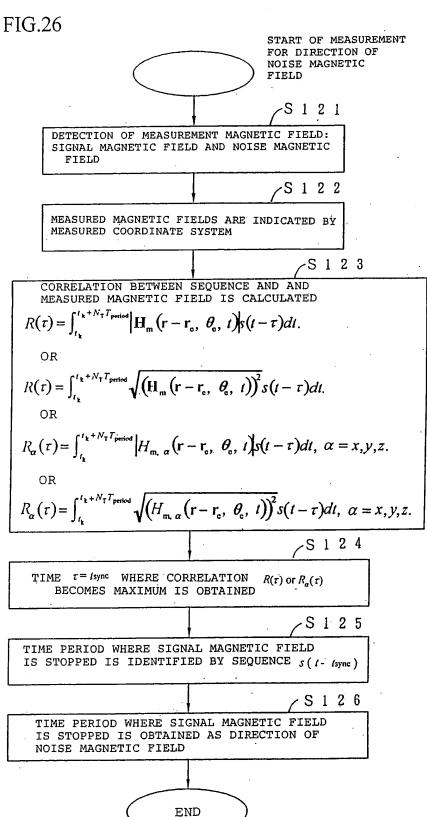




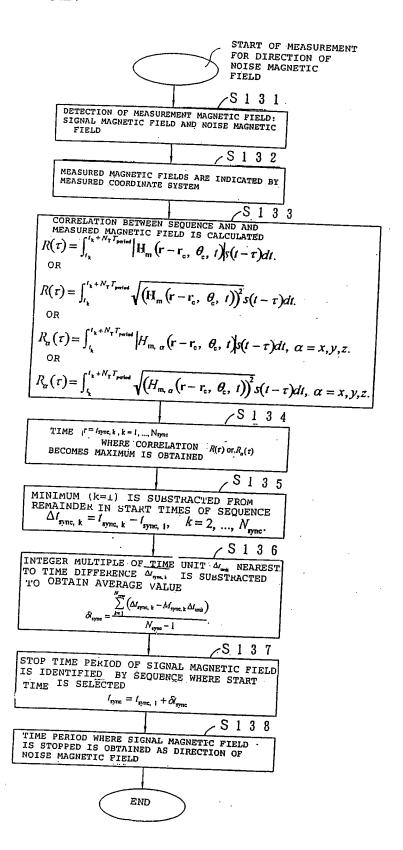
FIG.25











START OF MEASUREMENT FOR DIRECTION OF NOISE MAGNETIC FIELD S 1 4 1 DETECTION OF MEASUREMENT MAGNETIC FIELD: SIGNAL MAGNETIC FIELD AND NOISE MAGNETIC

S 1 4 2

MEASURED MAGNETIC FIELDS ARE INDICATED BY MEASURED COORDINATE SYSTEM

S 1 4 3

CORRELATION BETWEEN SEQUENCE AND AND MEASURED MAGNETIC FIELD IS CALCULATED

MEASURED MAGNETIC FIELD IS CALCULATED

$$R_{\alpha}(t_{k}) = \int_{t_{k}}^{t_{k}+T_{period}} \left| H_{m, \alpha}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, t) \right| s(t - t_{k}) dt,$$

OR

$$k = 1, ..., N_{\text{div}}; \alpha = x, y, z.$$

$$R_{\alpha}(t_{k}) = \int_{t_{k}}^{t_{k}+T_{period}} \sqrt{\left(H_{m,\alpha}(\mathbf{r}-\mathbf{r}_{o}, \theta_{o}, t)\right)^{2}} s(t-t_{k}) dt,$$
BUT
$$k = 1, \dots, N_{div}, \alpha = x, y, z.$$

$$t_k = t_0 + k \cdot T_{\text{div}}, \quad k = 1, ..., N_{\text{div}}.$$

$$S_{\rm mp}(t) = S(t + T_{\rm period})$$

$$S_{mp}(t) = S(t + T_{period}),$$

$$S_{mp}(t) = s(t), \quad 0 \le t < T_{period}.$$

S 1 4 4

PROJECTIVE COMPONENT VECTOR OF MEASURED MAGNETIC FIELD TO PLANE PERPENDICULAR TO VECTOR

 $e_n(t_k) = (R_x(t_k), R_y(t_k), R_z(t_k)), k = 1, ..., N_{div}.$ 

OF CORRELATION  $R_{\alpha}(t_k)$ ,  $k=1, \ldots, N_{d_{\alpha}}$ ;  $\alpha=x,y,z$ .

IS OBTAINED

 $H_{m}^{P}(r-r_{e}, \theta_{e}, t_{k}, t), k=1,..., N_{eq}$ 

S 1 4 5 a

4 IS CALCULATED SO THAT VARIANCE

$$\operatorname{var}(t_{k}) = \frac{\sqrt{\left\langle \left( \mathbf{H}_{m}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, t_{k}, t) - \left\langle \left| \mathbf{H}_{m}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, t_{k}, t) \right\rangle \right\rangle_{t}^{2}}}{\left\langle \left| \mathbf{H}_{m}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, t_{k}, t) \right\rangle \right\rangle_{t}^{2}}}$$

IS MINIMUM OR LESS THAN DETERMINED

$$e_n(t_k) = (R_k(t_k), R_y(t_k), R_z(t_k)), k = 1, ..., N_{div}.$$

CORRESPONDING TO tk IS SELECTED AS DIRECTION OF NOISE MAGNETIC FIELD

END



START O EASUREMENT FOR DIRECTION OF NOISE MAGNETIC FIELD

cS 1 4 1

DETECTION OF MEASUREMENT MAGNETIC FIELD: SIGNAL MAGNETIC FIELD AND NOISE MAGNETIC FIELD

S 1 4 2

MEASURED MAGNETIC FIELDS ARE INDICATED BY MEASURED COORDINATE SYSTEM

CORRELATION BETWEEN SEQUENCE AND AND MEASURED MAGNETIC FIELD IS CALCULATED

$$R_{\alpha}(l_{k}) = \int_{l_{k}}^{l_{k}+l_{point}} |H_{m, \alpha}(\mathbf{r} - \mathbf{r}_{e}, \mathbf{Q}_{e}, i)| \mathbf{r}(t - t_{k}) dt,$$

$$k = 1, \dots, N_{\text{div}}; \alpha = x, y, z.$$

$$R_{\alpha}(t_{k}) = \int_{t_{k}}^{t_{k}+T_{period}} \sqrt{\left(H_{m,\alpha}\left(\mathbf{r}-\mathbf{r}_{o},\ \theta_{o},\ t\right)\right)^{2}} s(t-t_{k})dt,$$

$$k = 1, \dots, N_{dir}; \ \alpha = x, y, z.$$

$$t_k = t_0 + k \cdot T_{\text{div}}, \quad k = 1, ..., N_{\text{div}}.$$

$$S_{mp}(t) = S(t + T_{period})$$

 $S_{mp}(t) = s(t), \quad 0 \le t < T_{period}$ 

S 1 4 4

PROJECTIVE COMPONENT VECTOR OF MEASURED MAGNETIC FIELD TO PLANE PERPENDICULAR TO VECTOR

 $\mathbf{e}_{a}(t_{k}) = \left(R_{x}(t_{k}) R_{y}(t_{k}) R_{z}(t_{k})\right) k = 1, \dots, N_{div}.$ 

OF CORRELATION  $R_{\sigma}(t_k)$ ,  $k=1, \dots, N_{\sigma \tau}$ ;  $\alpha=x,y,z$ . IS OBTAINED

 $\mathbf{H}_{\mathbf{m}}^{P}(\mathbf{r}-\mathbf{r}_{\epsilon},~\theta_{\epsilon},~t_{\mathbf{k}},~t),~k=1,...$ ,  $N_{\mathbf{m}}$ 

tk IS CALCULATED SO THAT FOR VARIANCE

$$\operatorname{var}_{\alpha}(t_{k}) = \frac{\sqrt{\left\langle \left(H_{m,\alpha}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, t_{k}, t) - \left\langle H_{m,\alpha}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, t_{k}, t)\right\rangle_{t}^{2}\right\rangle_{t}}}{\left\langle \left|H_{m}^{P}(\mathbf{r} - \mathbf{r}_{c}, \theta_{c}, t_{k}, t)\right\rangle_{t}}\right\rangle_{t}}$$

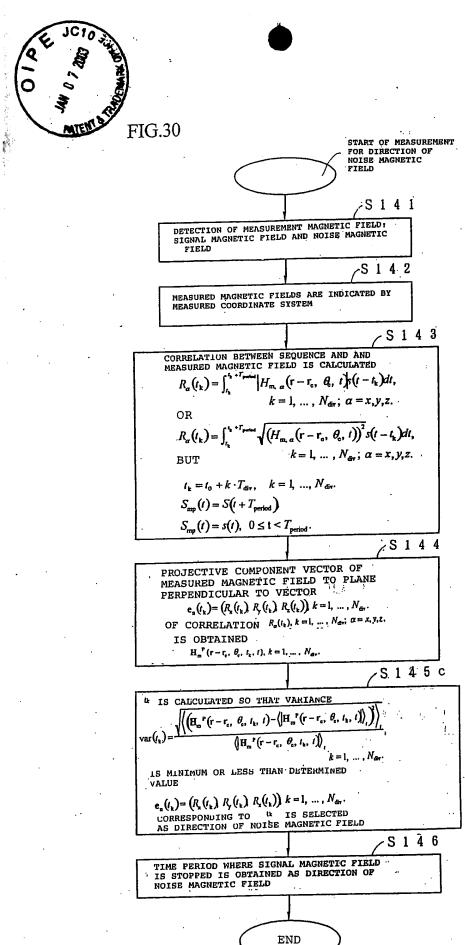
$$\sum_{\alpha=x,\,y,\,z} \operatorname{var}_{\alpha}(t_{\mathbf{k}})$$

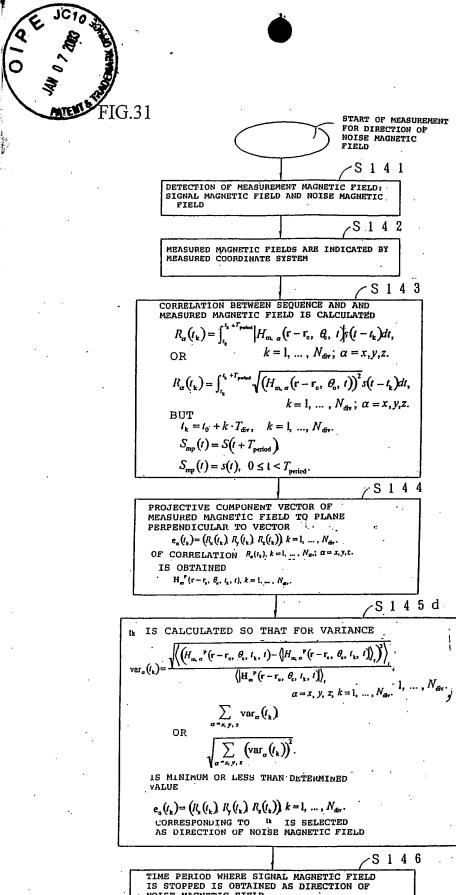
IS MINIMUM OR LESS THAN DETERMINED VALUE

$$e_n(t_k) = (R_k(t_k), R_k(t_k), R_k(t_k)) k = 1, ..., N_{div}$$
.

CORRESPONDING TO the IS SELECTED AS DIRECTION OF NOISE MAGNETIC BUT

AS DIRECTION OF NOISE MAGNETIC FIELD





TIME PERIOD WHERE SIGNAL MAGNETIC FIELD IS STOPPED IS OBTAINED AS DIRECTION OF NOISE MAGNETIC FIELD

END



